Description

METHOD AND APPARATUS FOR REINFORCING A LOAD BEARING MEMBER

Technical Field

[01] This invention relates to an apparatus for reinforcing a load bearing member and, more specifically, to such an apparatus and method thereof in which at least one failure-prone location on the load bearing member is identified and reinforced.

Background

[02] Load bearing members such as booms, sticks, crane booms and so forth typically must support loads which may produce a resultant load acting transversely across the member. Improvements in manufacturing processes such as welding processes allow for an improvement in the ability of the member to withstand loads. An example of such improvements would be an improvement in the quality of welds which decrease the extent of heat affected zones produced by the welding process. These improvements in the manufacturing processes, in turn, allow for use of thinner materials in creating these members resulting in possibly increased payloads and improved cycle times due to the decrease in weight of such structures. However, a point may be reached where the thickness of the member may be insufficient in a certain location or locations to support a desired loading condition. In such cases, it may be desirous to bolster these specific areas so as to allow the member to withstand the needed loading condition without sacrificing the minimization in the reduction in the weight of such members.

[03] Examples exist in the prior art which teach methods of reinforcing crane booms. Such examples can be found in, for example, U.S. Patent No.

4,112,649 which issued on Sept. 12, 1978 to Fritsch et al., U.S. Patent No. 4,027,448 which issued on June 7, 1977 to Tymciurak, and U.S. Patent No. 3,890,757 which issued on June 24, 1975 to Lamet et al. all of which teach truss-type support methods for providing additional reinforcement to a crane boom.

Summary of the Invention

[04] In accordance with an embodiment of the present invention a load bearing arrangement for use with a work machine of the type having a platform is provided where such an arrangement comprises at least on member coupled to the platform and having a longitudinal axis, and at least one reinforcing structure attached to the member at at least one identified failure-prone location.

[05] In accordance with another aspect of the present invention, a method for reinforcing a load bearing member for use with a work machine is provided comprising the steps of simulating a loading condition on the member, determining at least one location where the member is prone to buckling based on the simulation step, and proving the member with at least one reinforcing structure at that location.

Brief Description of the Drawings

[06] Fig. 1 is a side elevation view of an exemplary work machine embodying the principles of the present invention.

[07] Fig. 2 is an isometric view of a member comprising a boom embodying the principals of the present invention.

[08] Fig. 3 is an isometric view of a member comprising a stick embodying the principals of the present invention.

[09] Fig. 4 is a cross-sectional view taken through section 4-4 in Fig. 2.

[10] Fig. 5 is partial side view of the boom shown in Fig. 2.

[11] Fig. 6 is an isometric view of a member comprising a boom showing exemplary results of a buckling analysis.

Detailed Description

[12] With reference now to the Figures, shown in Fig. 1 is an exemplary work machine 100 incorporating the teachings of the present invention. The work machine 100 comprises a platform 101 onto which is mounted a plurality of load bearing members 105 embodied herein by a first member or boom 106 and a second member or stick 107. The boom 106 is pivotally connected to the platform 101 and moveable relative thereto by a first movement means embodied herein by a pair of first hydraulic actuators 110 which may comprise an extensible and retractable hydraulic cylinders. Likewise, the first end 111 of the stick 107 is pivotally coupled to the boom 106 via a suitable connector such as a pin 112 and is moveable relative to the boom 106 by a second movement means embodied herein by a second hydraulic actuator 114 which also may comprise an extensible and retractable hydraulic cylinder. It is to be understood that the work machine 100 shown herein is embodied by a barge unloader, however such a showing is exemplary only and it is contemplated that the teachings of the present invention may have wide applicability for work machines used to support loads such as, for example, backhoe loaders, excavators and so forth.

[13] Attached adjacent the second end 115 of stick 107, also by use of a suitable connector such as a pin 118, is an attachment 119 for use in grasping and holding a load of material which may comprise debris, dirt, rock, goods or other material types. The attachment 119 shown herein is embodied herein by a clamshell bucket although it is contemplated that such a showing is for purposes of illustration and not limitation and that other attachment types may also be used without deviating from the spirit of the present invention. The attachment 119 may also include a third hydraulic actuator (not shown) for use in activating the attachment 119.

[14] With reference now to Figures 2, the boom 106 is shown incorporating the teachings of the present invention. The boom 106 comprises a

pair of spaced apart side plates 200 each attached preferably by a robotic welding process to a top plate 201 and a bottom plate 202. The boom 106 includes a first end 205 comprising a pair of ears 206 wherein each ear 206 includes an aperture 209 for receipt of a pin (not shown) or other suitable device for pivotally coupling the boom 106 to the platform 101. The boom 106 also includes a second end 210 also having a pair of ears 213 each having an aperture 214 for receipt of pin 118. A tube 217 extends from each side plate 200 and is used to couple the first hydraulic actuators 110 to the boom 106. Coupling assembly 218 extend from the bottom plate 202 and are used to pivotably support the second hydraulic actuator 114 in a well known manner.

[15] Also shown in hidden detail in Figure 2 is a reinforcing structure 221 used to reinforce each of the side plates 200 against failure. Although the specific details of the reinforcing structure 221 will be explained in greater detail as this disclosure progresses, suffice to say for now the use of the reinforcing structures 221 of the present invention allows for the use of thinner side plates 200 while preventing buckling of the side plates 200 when load placed on the boom 106 reaches or exceeds a given amount.

[16] With reference now to Figures 3, the stick 107 is shown also incorporating the teachings of the present invention. The stick 107 also comprises a pair of spaced apart side plates 300 each attached, also preferably by a robotic welding process, to a top plate 301 and a bottom plate 302. The stick 107 includes the first end 111 sized to fit between the ears 213 of the second end 210 of the boom 106. The first end 111 further includes an aperture 306 for receipt of pin 111 thereby providing for the aforementioned pivotal attachment to the boom 106. The second end 115 of the stick 107 also includes an aperture 307 sized to receive pin 118. Coupling assembly 309 extend from the bottom plate 302 and is used to pivotably support the second hydraulic actuator 114 in a well known manner.

[17] Also shown in hidden detail in Figure 3 are a plurality of reinforcing structures each denoted by the reference numeral 310 which are used to reinforce each of the side plates 300 against buckling at pre-determined buckling prone areas. Although the specific details of the reinforcing structures 310 will also be explained in greater detail as this disclosure progresses, suffice to say for now the use of the reinforcing structures 310 of the present invention also allows for the use of thinner side plates 300 on the stick 107 while preventing buckling of the side plates 300 at pre-determined buckling prone areas when loads placed on the stick 107 reach or exceed a given amount.

[18] With reference to the discussion accompanying Figure 6 below, it should be appreciated by those of ordinary skill in such art, that the number of reinforcing structures 221,310 to be used is a matter of design selection and need not constitute any more than is necessary to achieve the needed performance, and by limiting the number of reinforcing structures 221,310 used the weight of the boom 106 and the stick 107 may be minimized.

[19] With reference to the cross-sectional shown in Fig. 4, the location and configuration of the reinforcing structures 221,310 will now be discussed. For purposes of brevity the following discussion will be limited to the reinforcing structure 221 for the boom 106, however it is to be understood that the disclosure herein is equally applicable to the reinforcing structures 310 used for the stick 107. As shown, at least one reinforcing structure 221 is attached to an inner surfaces 400 of the side plates 200 by a suitable attachment method preferably a laser welding method. As should be appreciated by those of ordinary skill in such art, it has been found that the use of laser welding to attach the reinforcing structure 221 to the side plates 200 reduces the heat effected zone surrounding the weld area, thereby allowing for thinner side plates 200 then would otherwise be required for different welding-type attachment methods. It is to be understood that the attachment location of each reinforcing structure 221 is exemplary only and it is contemplated that other attachment locations for the reinforcing

structures 221 may be had such as, for example, the outer surface 401 of each of the side plates 200.

[20] As shown, each reinforcing structure 221 comprises a substantially straight member having a base portion 404 and a rib portion 405 extending from the base portion 404. The reinforcing structure 221 may comprise a metallic or other rigid material and has a length which is user-selected based on the failure analysis performed on at least one of the members 105 and to be discussed with reference to Fig. 6. Furthermore, it is also contemplated that other geometry's for the reinforcing structure 221 may also be used with deviating from the spirit of the present invention such as, for example, a cylindrical or flat configuration.

[21] With reference now Fig. 5, a partial elevational view of the stick 107 is shown. Again, for the purpose of brevity, the following discussion will be in reference to the stick 107 but it is to be understood that the description provided herein applied equally as well to the boom 106. The reinforcing structure 310 is shown in hidden detail attached to the side plate 300 in an exemplary orientation β relative to the boom longitudinal axis 500. As should be appreciated by those of ordinary skill in such art, each reinforcing structure 310 may be attached to the side plate 300 at a user-selected orientations or angles β relative the boom's longitudinal axis 500 which can vary between zero (0) degrees and ninety (90) degrees.

[22] Shown in Fig. 6 is an exemplary diagram of the results of a buckling analysis performed on, for example, the boom 106. As shown, the area denoted 600 protruding from the side plate 200 represents the location of the side plate 200 which is prone to buckling as based on a simulated load placed on the boom 106. Although a variety of methods can be used to provide the aforementioned analysis, software programs such as, for example, Nastran (TM) can be used in conjunction with a computing system (not shown) to model loading characteristics on the boom 106 and stick 107 and obtain the aforementioned information related to buckling prone areas. Based on the

information obtained from the aforementioned buckling analysis, the overall length of each reinforcing structure 221, 310 as well as size of the respective base and rib portions 404, 405 may be chosen without undue experimentation.

Industrial Applicability

[23] In use and in operation, each reinforcing structure 221,310 may be located on the boom 106, the stick 107, or both so as to bolster those identified failure-prone areas 600 which may be prone to buckling when subject to loads meeting or exceeding a certain level. As should be appreciated by those of ordinary skill in such art, by locating the reinforcing structures 310 in only those areas which require the needed support, the weight of the boom 106 and stick 107 may be kept to a minimum, thereby providing for increased payloads and reduced cycle times for a any given job. Modeling programs such as Nastram (TM) which are typically used with computing systems may be used to identify potential areas of the boom 106 and stick 107 which may be subject to failure. As should be appreciated by those of ordinary skill in such art, by identifying failure prone locations of the boom 106 and stick 107, the size and location of each reinforcing structure 221,310 may be optimized so as to minimize the weight of the boom 106 and stick 107; thereby increasing the potential payload of the work machine 100.

[24] Other aspects, objects and advantages of this invention can be obtained from a study of the drawings, the disclosure and the appended claims.